Digibus

Digibus: Automated Driving

Results from a 7-month field trial

Dr. Karl Rehrl, September 2017

Salzburg Research Forschungsgesellschaft mbH

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Salzburg Research in a nutshell

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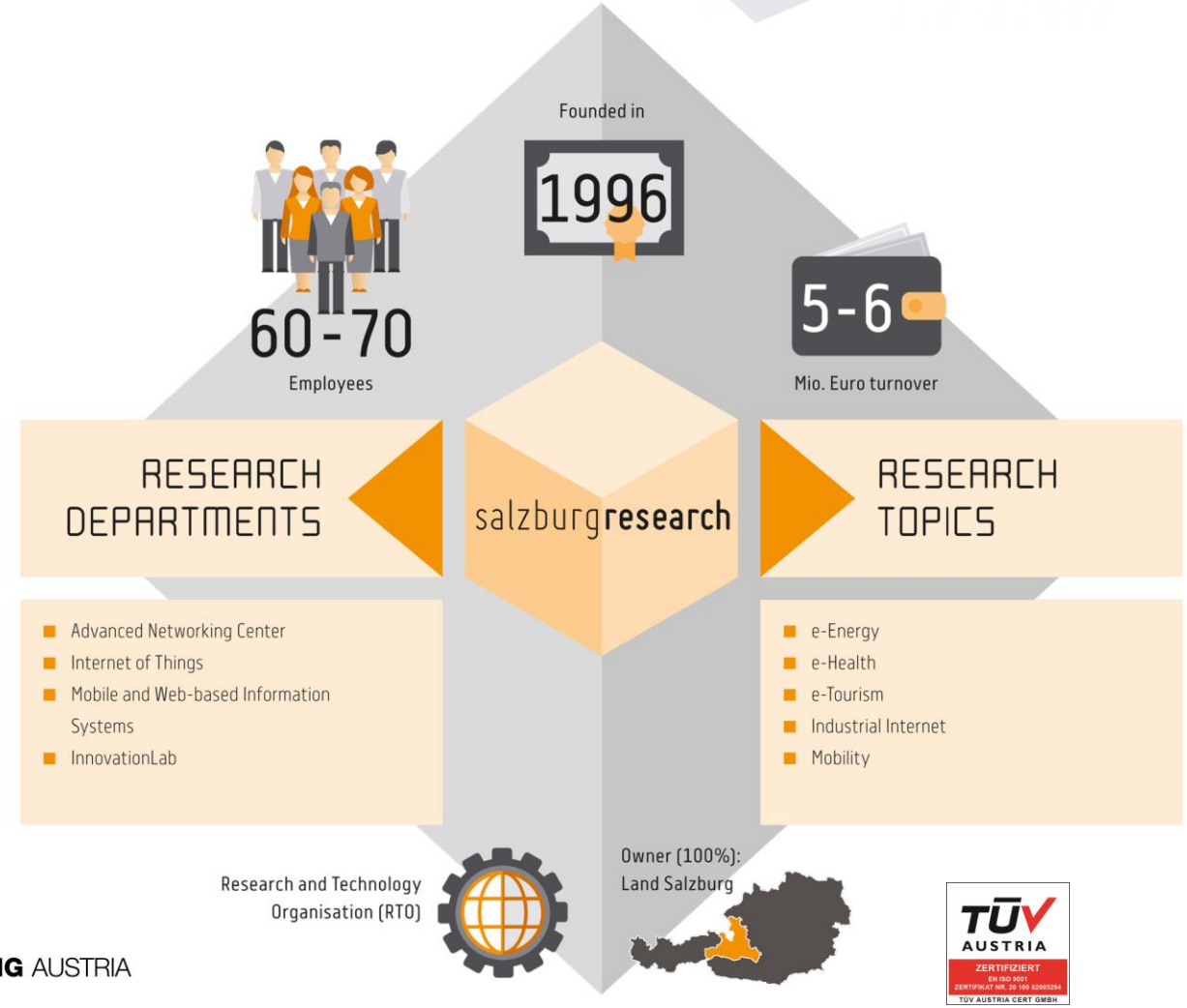

FORSCHUNG AUSTRIA

TÜV AUSTRIA ZERTIFIZIERT

Personal Background

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- Karl Rehrl, born 28.03.1978, Vöcklabruck, Upper Austria
- Diploma degree in Computer Science from the Johannes Kepler University of **Linz**, 1997-2002
- Doctoral degree in Geoinformation and Surveying from the Technical University of **Vienna**, 2007-2011
- Research Associate at Salzburg Research (2002-2004)
- Founder and Head of Mobile and Web-based Information Systems Group at Salzburg Research (since 2004)
- Associate Lecturer at TU Vienna (since 2013) and Carinthia University of Applied Sciences (since 2014)
- Member of the Austrian ITS Board (since 2012)

Automated driving: The road to full autonomy

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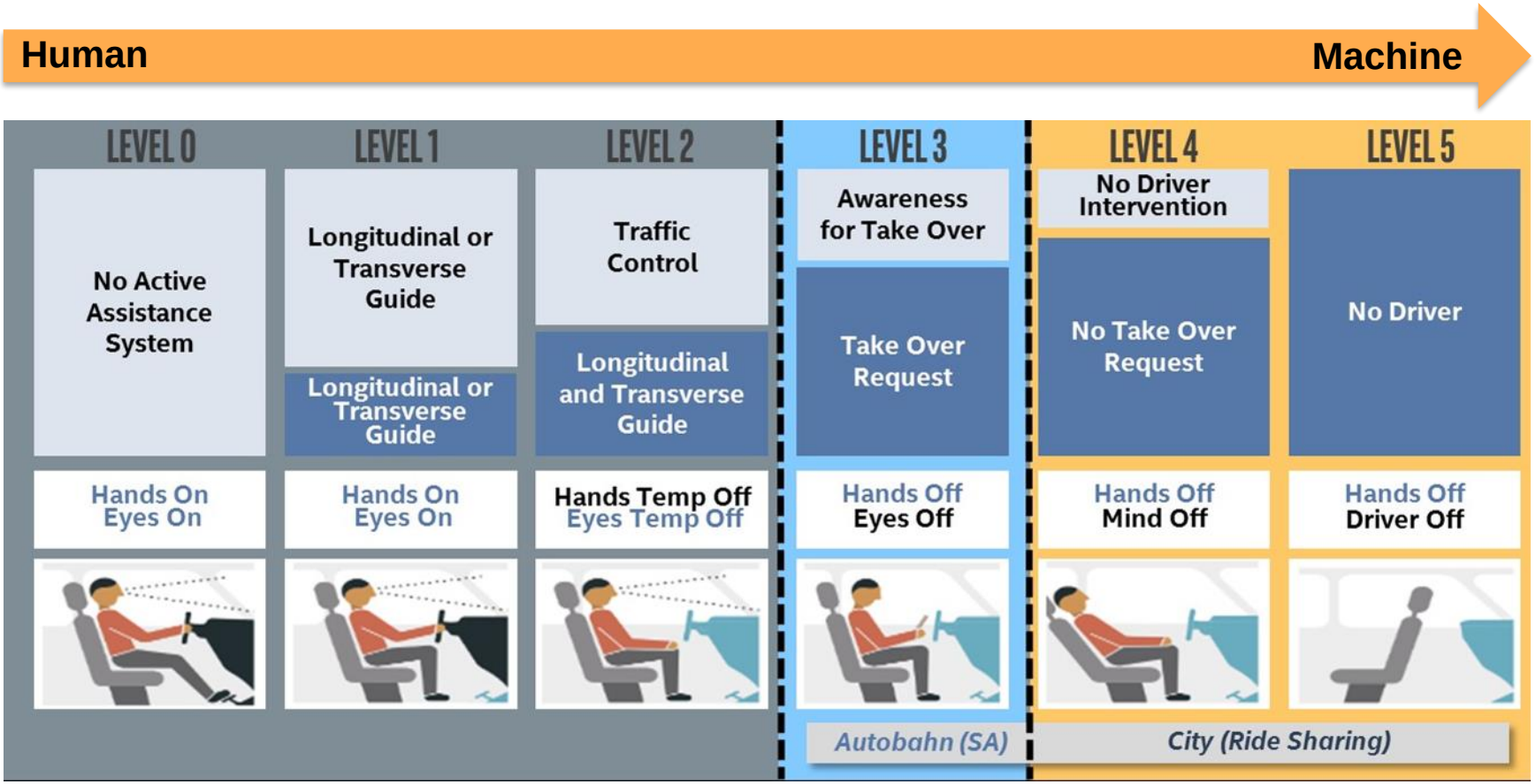

SAE International J3016

Automated minibuses: „first/last mile“ scenario

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Navya Arma	Easymile EZ 10	Local Motors Olli
		

- New vehicle concepts – Start-ups, prototypes, a lot of conceptual work
- Few manufacturers – no mass market, no mature products
- Disruptive development – are we really talking “level 5”?
- Big hype, sales orientation – a long way to go/drive

The international perspective

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Olli, Berlin

WEPods, NL

DB, Bad Birnbach

Navly, Lyon

Digibus, Salzburg

SMART, Singapur

Mcity, Michigan

SmartShuttle, Sion

RAC Intellibus, Perth

Austria‘s roadmap

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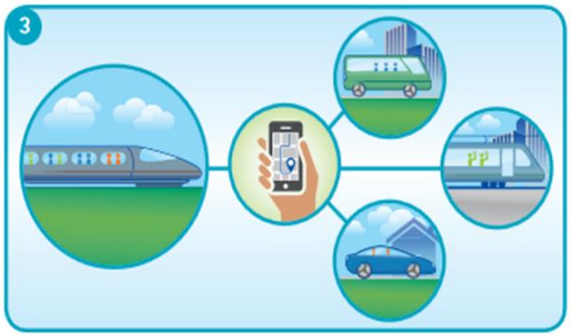
- In 2016, the federal ministry of transport published a „**action plan for automated driving“**
  (https://www.bmvit.gv.at/innovation/publikationen/verkehrstechnologie/automatisiert.html)
- This includes several Use Cases – we address use case **3 „New flexibility through automated and connected vehicles“**.

Use Case 3:
„Neue Flexibilität"
Automatische und vernetzte Fahrzeuge ermöglichen hohe Flexibilität in einem intermodalen Verkehrssystem. Routenoptimierung, an persönliche Vorlieben und Wünschen angepasste Fahrtzeiten, sichere und komfortable Anschlussmobilität an intermodalen Umstiegspunkten inkludieren neue Fahrzeugkonzepte und Informations- und Buchungsdienste.



- The action plan also includes funding for **testbeds, research projects**, …
- And it includes a **legal framework** for doing the tests on public roads

December 19, 2016: The „AutomatFahrV“-Act

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- A **legal frame** for tests on public roads issued by the ministry of transport
- **3 test cases**
  1. **Automated minibus**
  2. Highway pilot
  3. Automated military vehicle
- Automated Minibus
  - Driver on board at all times
  - 20 km/h top speed
  - Danger stop, accident recorder
  - Insurance, test drive number plates
- Certificate issued to Salzburg Research on April 18, 2017

April 24, 2017: Kick-off for a 7-months test in Salzburg (in the village of Koppl) focusing on the “first/last mile”

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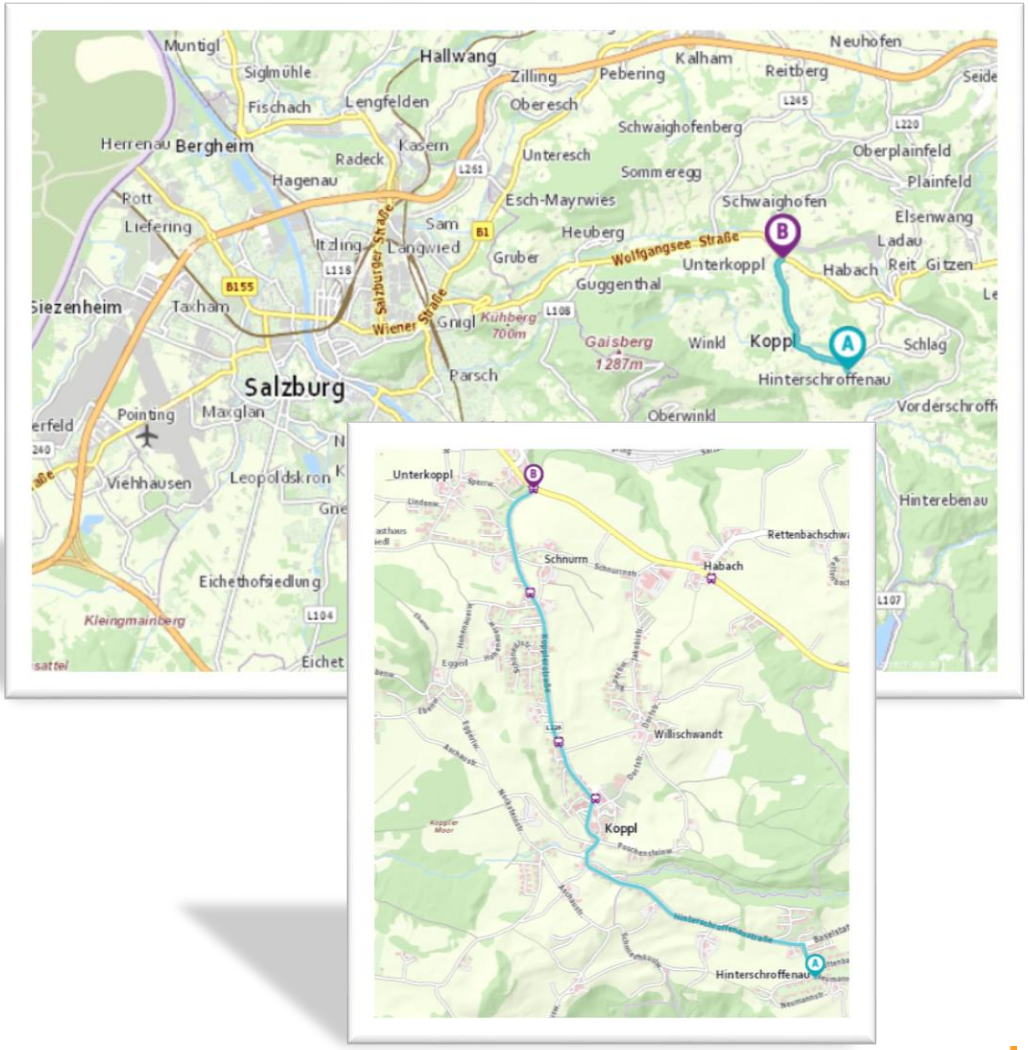
Test track Koppl

- Village of Koppl
  - Inhabitants: 3.305
  - Households: 1.243
- Test Track
  - 1,4 km (+1,4 km to next village)
  - Asphalted road, two lanes
  - 65 m elevation, max. 8% incline
  - No road markings
- Public Transport Situation
  - Bus line 152 (feeder to line 150)
  - 4 stops
  - Operated only 6 times a day



Test track Koppl – Stepwise deployment

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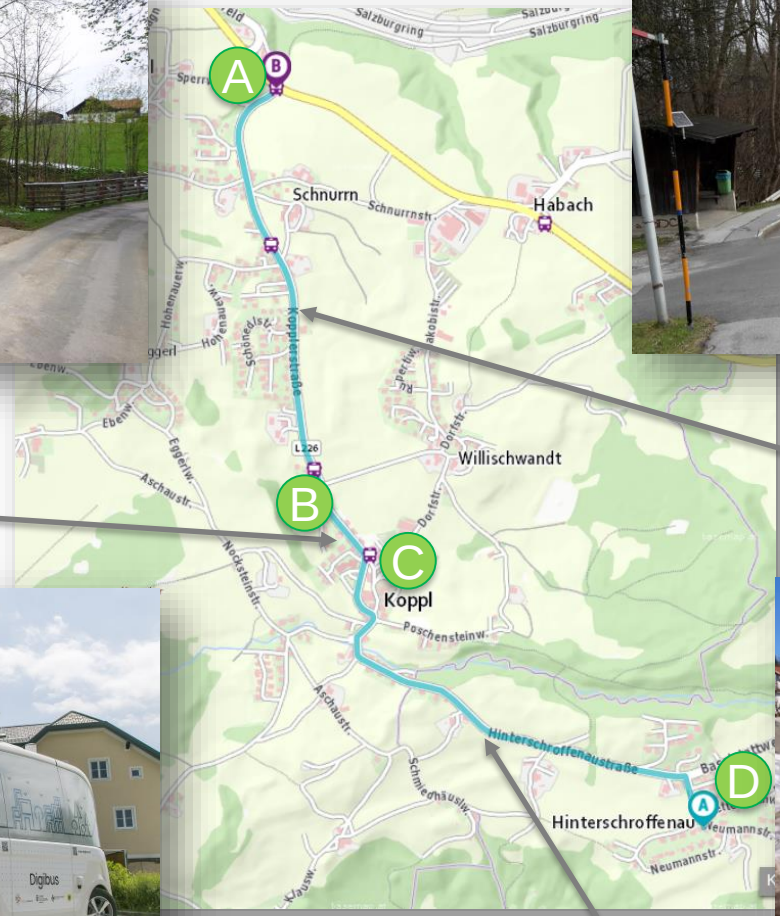


Track Sperrbrücke – Ortszentrum (A-C), appx.1,4 km

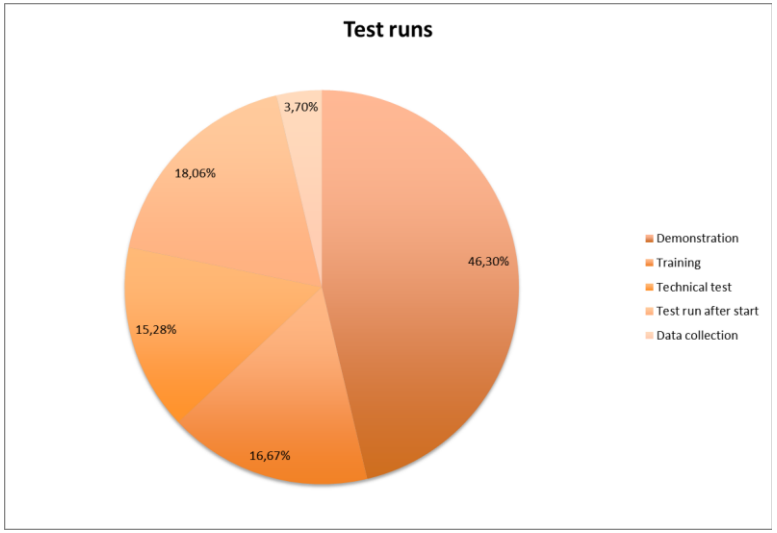
Demonstration (B-C), appx. 200 m

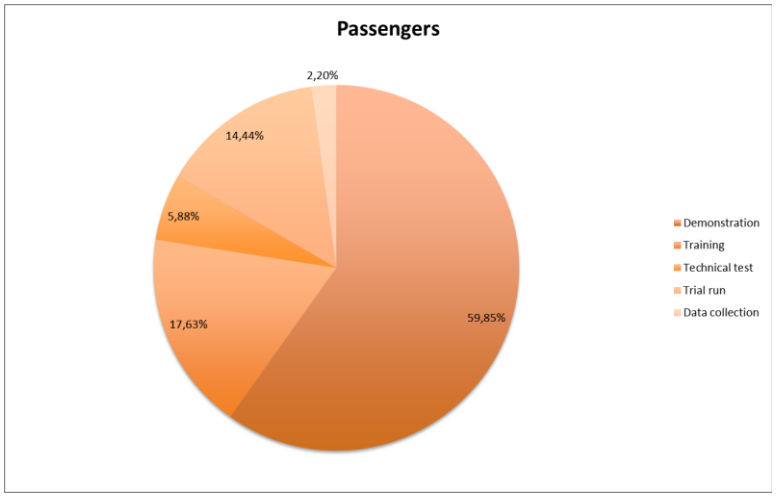
Extension Ortszentrum – Hinterschroffenau (C-D), appx.1,4 km

Protocol of test runs

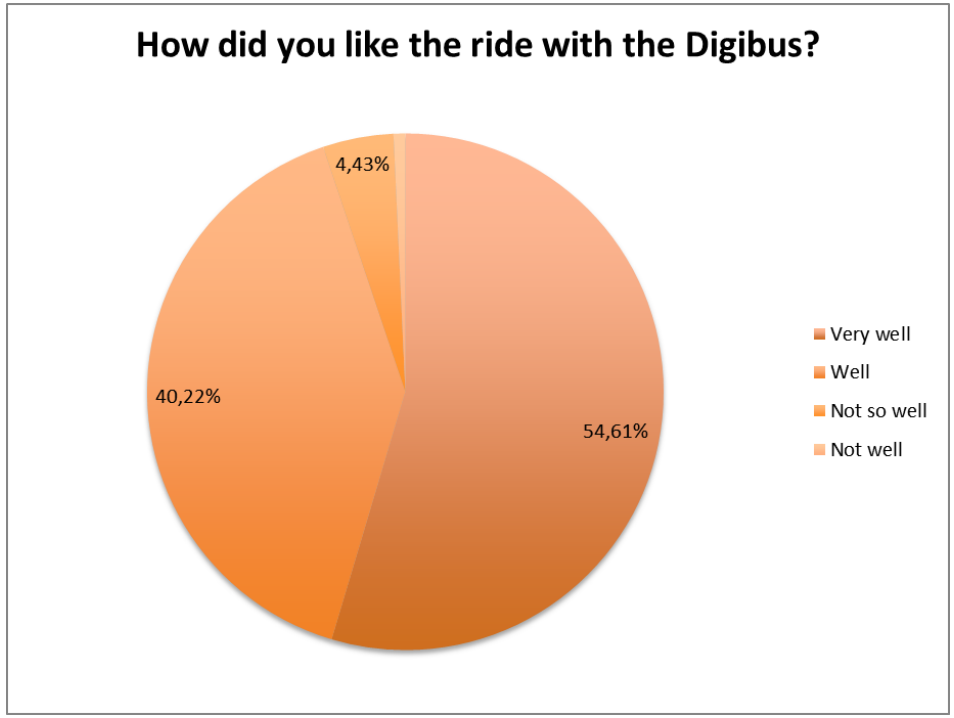
- Test runs 216
  - Demonstration 100
  - Training 36
  - Technical tests 33
  - Test runs after start-up 39
  - Data collection 8

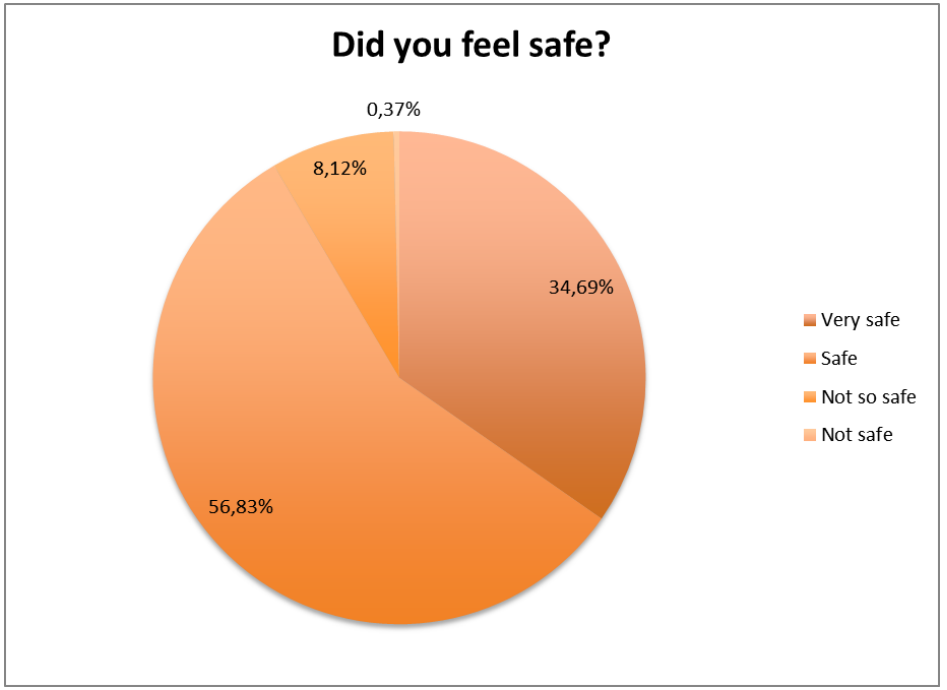
- Passengers 817
  - Demonstration 489
  - Training 144
  - Technical tests 48
  - Test runs after start-up 118
  - Data collection 18





Passengers: High acceptance / feeling of safety





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What did you like? (Excerpt)

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- Smooth driving / low noise level
- Comfortable
- Pedestrian recognition
- Interior / design
- Good feeling of safety
- New driving experience / self-driving feature is interesting
- Small turn radius
- Accuracy of positioning

„Perfect technology, well puzzled out. I‘m enthusiastic.“

„Obviously it works well.“

What was surprising? (Excerpt)

- Abrupt braking / braking characteristic
- Complexity of normal traffic situations
- Technical achievements
- Obstacles: intensive development and learning necessary
- Slow speed
- Poor interaction possibilities on touch display

„Surprisingly simple.“

„I‘m surprised that the bus has recognized every obstacle.“

Why did you feel unsafe? (Excerpt)

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- Poor trust in technology
- Abrupt braking – other traffic participants may feel unsafe
- Lack of experience
- Not really self-driving => manual interaction necessary
- Seat in the opposite direction of travel behind the windshield
- Jerking
- Does not recognize traffic signs and differences between vehicles and human beings

Acceptance of other traffic participants

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- Partly thoughtful, partly not
- Slow speed (at the moment 15 km/h)
- Rush hours are challenging (commuter traffic)
- Communication problems with other traffic participants
  - How does the automated vehicle behave?
  - How should the behavior of the vehicle shared with others?
  - Can I trust the vehicle?
- Learning effects of other traffic participants
- Own experiences help in understanding the behavior

Experiences / challenges

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- Early, formative phase, high expectations, many risks
  - Minibuses are at prototype level
  - Poorly tested, only simple traffic situations can be handled automatically
  - Manufacturers learn from real-world tests
  - Technology is far not ready for regular operation
- Aspects / Questions
  - Simulation vs. test environments vs. open roads
  - Motorway vs. urban environment vs. rural environment
  - Car industry vs. IT industry vs. startups
  - Individual traffic vs. public transport vs. individual public transport
  - Expectations vs. experiences

Experiences / challenges

- Positioning
  - LIDAR-Positioning works well only in urban settings
  - Lack of road markings in rural areas
  - GNSS-RTK: Partly poor coverage, no reliable correction signal
- Environmental recognition
  - Reliable recognition of static obstacles
  - Poor detection of moving vehicles (especially at higher speeds)
  - Problems with dead angles, reflections, aso.
  - No object classification
- Driving situations / maneuvers
  - Have to be pre-defined manually, e.g. priority rules
  - Vehicle stops in front of obstacles, no dynamic maneuvers
  - High complexity of simple driving situations

Conclusions

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- Self-driving minibuses are on the market and ready to test
- Tests on open roads are possible and necessary
- Legal frame exists and should be used
- Technology needs systematic further development and testing

- Passengers' acceptance? -> Surprisingly good (bias!)
- Other traffic participants' acceptance? -> Mixed
- Operators' acceptance? -> Skeptical

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Join us at the E-Mobility-Play Days: 29.-30.9.2017, Red Bull Ring Styria

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